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GEOGRAPHICAL NOTES,

BY

GEO. C. HURLBUT, *Librarian.*

THE BRITISH ASSOCIATION.—The meeting of the British Association for the Advancement of Science was opened in the Sheldonian Theatre, Oxford, on the 8th of August, with an address by Lord Salisbury, who, as Chancellor of the University of Oxford, tendered the welcome which it was his duty, as President of the British Association, to accept.

In his address, which was equally solid and brilliant, he called attention to some of the problems that still defy investigation—the enigma of the elements, the inscrutability of the ether, the central mystery of life, evolution, and the hypothesis of natural selection—and he quoted, as his own concluding words, the language with which Lord Kelvin* closed his presidential address more than twenty years ago:

> I have always felt that the hypothesis of natural selection does not contain the true theory of evolution, if evolution there has been in biology. * * * I feel profoundly convinced that the argument of design has been greatly too much lost sight of in recent zoological speculations. Overpoweringly strong proofs of intelligent and benevolent design lie around us, and if ever perplexities, whether metaphysical or scientific, turn us away from them for a time, they come back upon us with irresistible force, showing to us through nature the influence of a free will, and teaching us that all living things depend on one everlasting Creator and Ruler."

Captain W. J. L. Wharton, R. N., F. R. S., President of the Section of Geography, delivered the following address*:

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* Better known as Sir William Thomson.

You will not be surprised if, having called upon an hydrographer to preside over this Section, he takes for the subject of his review the Sea. Less apparently interesting, by reason of the uniformity of its surface, than the land which raises itself above the level of the waters, and with which the term geography is more generally associated, the ocean has, nevertheless, received much attention of later years. In Great Britain, especially, which has so long rested its position among the nations upon the wealth which our merchant fleets bring to its shores, and upon the facilities which the sea affords for communication with our numerous possessions all over the globe, investigation into the mysteries, whether of its ever moving surface or of its more hidden depths, has been particularly fascinating. I purpose, therefore, to attempt a brief survey of our present knowledge of its physical condition.

The very bulk of the ocean, as compared with that of the visible land, gives it an importance which is possessed by no other feature on the surface of our planet. Mr. John Murray, after a laborious computation, has shown that its cubical extent is probably about fourteen times that of the dry land. This statement appeals strongly to the imagination, and forms, perhaps, the most powerful argument in favor of the view, steadily gaining ground, that the great oceans have in the main existed in the form in which we now see them since the constituents of the earth settled down into their present condition.

When it is considered that the whole of the dry land would only fill up one-third of the Atlantic Ocean, the enormous disproportion of the two great divisions of land and sea becomes very apparent.

The most obvious phenomenon of the ocean is the constant horizontal movement of its surface waters, which in many parts take well-defined directions. These great ocean currents have now been studied for many years, and our knowledge of them is approaching a point beyond which it is doubtful whether we shall ever much advance, except in small details. For though, while indisputably the waters continually move in each great area in generally the same direction, the velocities vary, the limits of the different streams and drifts vary, mainly from the ever-varying force and direction of the winds.

After long hesitation and much argument, I think it may be now safely held that the prime motor of the surface currents is the wind. Not, by any means, the wind that may blow, and even persistently blow, over the portion of water that is moving, more or less rapidly, in any direction, but the great winds which blow generally from the same general quarter over vast areas. These, combined with deflection from the land, settle the main surface circulation.

I do not know if any of my hearers may have seen a very remarkable model, devised by Mr. Clayden, in which water disposed over an area shaped like the

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* Reprinted from *Nature*, of August 16.

Atlantic, and sprinkled over with lycopodium dust to make movement apparent, was subjected to air impelled from various nozzles, representing the mean directions of the permanent winds. It dispelled the last doubt I held on the subject, as not only were the main currents reproduced, but the smaller effects and peculiarities of the Atlantic drifts were produced with surprising accuracy.

There is a small current, long shown on our charts, but which I had always regarded with suspicion. I refer to the stream which, after travelling from the Arctic Ocean southward along the east coast of Greenland, turns sharply round Cape Farewell to the northward into Davis Straits, where it again doubles sharply on itself to the southward. This is exhibited, in the model, in all its details, and is evidently caused by the pressure of the water forced by the mimic Gulf Stream into the Arctic region, where it has no escape except by this route, and is pressed against the land, round which it turns as soon as it can. This is, no doubt, the explanation of the real current.

The very remarkable winter equatorial current, which runs in a narrow belt eastwards, just north of the main stream travelling west, was also reproduced with extraordinary fidelity.

The winds, however, that are ordinarily considered permanent vary greatly, while in the monsoon areas the reversal of the currents caused by the opposite winds exercises a great influence on the movements of the water far beyond their own limits, and anything like a prediction of the precise direction and rate of an oceanic stream can never be expected.

The main facts, however, of the great currents can be most certainly and simply explained in this manner.

The trade winds are the prime motors. They cause a surface drift of no great velocity over large areas in the same general direction as that in which they blow. These drifts after meeting and combining their forces eventually impinge on the land.

They are diverted and concentrated and increase in speed. They either pour through passages between islands, as into the Caribbean Sea, are pressed up by the land, and escape by the only outlets possible—as, for example, the Strait of Florida, and form a great ocean current like the Gulf Stream—or, as in the case of the Agulhas current and the powerful stream which runs north along the Zanzibar coast, they are simply pressed up against and diverted by the land, and run along it with increased rapidity.

These rapid currents are eventually apparently lost in the oceans, but they in their turn originate movements of a slower character, which on again passing over shallow water or on meeting land develop once more into well defined currents.

We find an analogous state of things on the western side of the Pacific, where the Japan current is produced in a similar manner.

The fact that on all western shores of the great oceans towards which the trade winds blow we find the strongest currents running along the coast, is almost enough of itself to prove the connection between them.

The westerly winds that prevail in higher northern and southern latitudes are next in order in producing great currents. From the shape of the land they in some cases take up and continue the circulation commenced by the trade winds; in others they themselves originate great movements of the water.

Compared to the great circulation from this source, the effect of differences of temperature or of specific gravity is insignificant, though no doubt they play their part, especially in causing slow under-circulation, and in a greater degree the vertical mixing of the lower waters.

No drop of the ocean, even at its greatest depth, is ever for one moment at rest.

Dealing with minor points, the American officers of the Coast and Geodetic Survey have found after long and patient investigation that the velocity of the Gulf Stream in its initial and most marked part, the Strait of Florida, is greatly affected by the tide, varying as much as one-half its maximum rate during the twenty-four hours.

These American investigations are of greatest interest. They have extended over the whole area of the Caribbean Sea and its approaches, the Gulf of Mexico, and the Gulf Stream proper and its vicinity. In no other part of the ocean has observation of this detailed character been carried out, and they throw a great light on oceanic circulation. The *Blake*, the vessel specially fitted for the purpose, has during the several years in which she was employed on this work anchored in over 2000 fathoms of water, or a depth of considerably more than two miles ; a feat which would a short time ago have been deemed impossible.

One great point that has come out very strongly is the continual variation in the strength and direction of the currents, and the varying depths to which the surface current extends.

Eastward of the chain of the Windward Islands the general depth of the surface movement may be said to be about 100 fathoms, below which tidal influence is very distinct.

There is also a very plain backward flow of water, at depths which vary, caused by the submarine ridge which connects the Windward Chain of the West Indian Islands. These observations also generally support what I have already mentioned : that the velocity of a current depends on the strength of winds, possibly thousands of miles distant, which have given the original impetus to the water, and this, combined with tidal action when the current approaches or runs along a coast, will always cause uncertainty on the resultant velocity.

Dealing for yet another moment with the Gulf Stream, there are two points which have not been much dwelt upon, but which have a great effect on its power of bringing the modifying influence of its warm water as far as our shores.

The first is the prevention of its spreading, as it leaves the Strait of Florida, by the pressure of the portion of the equatorial current which, unable to get through the passages between the Windward Islands, is diverted to the north of the Bahamas, and bears down on the eastward side of the Gulf Stream proper, compressing it between itself and the cold water flowing southward along the American coast, and at the same time adding to its forces and maintaining its high temperature.

The second is that by the time the Gulf Stream has lost its velocity as a current in about the vicinity of the Banks of Newfoundland, it has arrived in the region of the westerly winds, that is, of winds whose average direction is from west; whose influence, causing a surface drift somewhat comparable to that of the trade winds, bears the water onward to the British Islands and Norway. Without these prevailing westerly winds the warm water of the Gulf Stream would never reach these shores.

The depth to which the surface currents extend in other parts is little known. Direct observations on under-currents have been rare.

In the first place, it is not an easy observation to make. Apparatus has generally to be improvised. This has usually consisted of some form of flat surface lowered to the required depth, and suspended in the water by a buoy, which presents to the resistance of the upper stratum a very much smaller area than that of the surface below.

More perfect machines have been devised, notably that used by the Americans in their West Indian experiments.

These, however, are delicate, and require so much care and experience in working, and so much time is wanted for such observations, that under the pressure of the more urgent requirements on surface movements in the interests of navigation very little has been done.

The *Challenger* made some observations on the depth of the equatorial current in mid-Atlantic, but they were not very conclusive for lack of suitable appliances. They, however, tended to show that below 100 fathoms there was but little current.

It has been calculated theoretically that winds blowing steadily in one direction with the ordinary force of the trade winds would, in 100,000 years, by friction between the particles, put the whole of a mass of water 2,000 fathoms deep, not otherwise influenced, into motion in that direction; but the direction and force of the trade winds are ever changing, and the actual strong currents of the ocean are not in the trade wind areas, but are the result of these drifts meeting one another and being compressed by the conformation of the land. We cannot, therefore, expect this theoretical effect to be realized.

One instance of the underrunning of one current by another is brought very plainly to our notice in the North Atlantic, to the east of the Great Banks of Newfoundland, where the icebergs borne by the Arctic current from Baffin Bay pursue their course to the southward across the Gulf Stream running eastward.

These great masses of ice, floating with seven-eighths of their volume under the surface, draw so much water that they are all but wholly influenced by the under-current. A large berg will have its bottom as much as six or seven hundred feet below the surface. The only reason that these bergs continue their journey southward is the action of the cold under-current.

It was my good fortune to be ordered in 1872 to undertake a series of experiments of the currents and under-currents of the Dardanelles and Bosporus. They proved most interesting.

It was well known that a surface stream is almost continuously passing out of the Black Sea through the Bosporus into the Sea of Marmara, and again through the Dardanelles into the Mediterranean. Certain physicists, of whom Dr. W. Carpenter was one, were, however, of opinion that a return current would be found under the surface running in the opposite direction, and this I was enabled to demonstrate.

Though from the imperfection of our apparatus, which we had to devise on the spot, we were unable to exactly proportionate the quantities of water moving in the two directions, we found, whenever the surface current was rushing south-westward through these straits, that for a certain distance, from the bottom upwards, the water was in rapid motion in the opposite direction. It was an astonishing sight to behold the buoys which supported a wooden framework of 36 square feet area, lowered to depths from 100 to 240 feet, tearing up the straits against a strong surface current of as much as three and four miles an hour. It was as perfect an ocular demonstration of a counter under-current as could be wished, and the Turks, who watched our proceedings with much suspicion, were strongly of opinion that the devil had a hand in it, and only the exhibition of the Sultan's firman saved us from interruption. In the investigation of these currents we found, as usual, that the wind was the most potent agent. Though the surface water from the Black Sea is almost fresh, and the bottom water of the heavy Mediterranean density of 1.027, it was found that when calm had prevailed the surface current slackened, and at times became nil, whilst the under-current responded by a similar slackening.

The ordinary condition of wind in the regions of the Black Sea and Sea of Marmara is that of a prevalent north-east wind. This causes a heaping up of the water on the south-west shores of those seas, precisely where the straits open, and the surface water, therefore, rapidly escapes.

These straits, no doubt, present abnormal characters, but, so far as surface currents are concerned, the long series of observations then made convinced me of the inadequacy of differences of specific gravity, which were here at a maximum, to cause any perceptible horizontal flow of water.

I have said that we were unable to define by direct observation the exact position of the dividing line between the opposing currents, but the rapid change in the specific gravity at a certain depth, which varied on different days, gave a strong indication that the currents changed at this point.

A Russian officer, Captain Makaroff, afterwards made similar experiments in the Bosporus, but with more perfect appliances, and he found that at the point where the specific gravity changed the currents also changed.

I have been anxious to obtain similar observations at the Straits of Bab-el Mandeb, the southern outlet of the Red Sea, where somewhat similar conditions prevail. Here the winds are governed by the monsoons. For half the year the wind blows from the north down the whole length of the sea, causing a surface flow outwards into the Gulf of Aden, and a general lowering of the whole level of the sea of about two feet. For the other half of the year the wind at the southern end of the sea is strong from the south-east, causing a surface set into the Red Sea, over which the general level of the water rises, while the northerly wind continues to blow throughout the northern half.

At either of these times I think it is highly probable that there is an under-current in the opposite direction to that at the surface, but unfortunately the sea disturbance is great and observations are very difficult.

Observations were, however, made by Captain W. U. Moore in H.M.S. ***Penguin*** in 1890, but at a time when the change of monsoon was taking place.

The result was peculiar, for it appeared that at a depth of about 360 feet the movement of the water was tidal, while the surface water was moving slowly in one direction—a result generally similar to that obtained by the Americans in the West Indies—but the direction of the tidal flow was directly opposite to what might have been expected, viz., the water ran in while the tide fell, and *vice versa*.

More observations are, however, needed here before any certain conclusions can be formed.

The depth of the ocean is the next great feature which demands attention.

On this our knowledge is steadily, though slowly, increasing.

The whole of it has been gained during the last fifty years.

Commenced by Sir James Ross, whose means were very small, but who nevertheless demonstrated that the so-called unfathomable ocean was certainly fathomable everywhere, the sounding of the ocean has continuously proceeded. The needs of submarine cables have constantly demanded knowledge in this particular, and the different cable companies have had a large share in ascertaining the facts.

Expeditions, whose main object has been to obtain soundings, have been sent out, Great Britain and the United States taking the first place; but most maritime nations have aided.

In the immediate past the additions have mainly been from the soundings which H. M. surveying ships continually take whenever on passage from one place to another, from the work of our cable companies, and from United States vessels.

We have, as a result, a very fair general knowledge of the prevailing depths in the Atlantic, but of the Indian and Pacific Oceans it is very fragmentary. We have enough to give us a general idea, but our requirements increase as years roll on. It is a vast task, and, it may be safely said, will never be completed; for we shall never be satisfied until we know the variations of level under the water as well as we know those on the dry land.

It is hopeless to do more than to briefly sketch the amount of our knowledge.

First, as to the greatest depths known. It is very remarkable, and from a geological point of view significant, that the very deepest parts of the ocean are not in or near their centres, but in all cases are very near land.

One hundred and ten miles outside the Kurile Islands, which stretch from the northern point of Japan to the north-east, the deepest sounding has been obtained of 4,655 fathoms, or 27,930 feet. This appears to be in a deep depression, which runs parallel to the Kurile Islands and Japan; but its extent is unknown, and may be very large.

Seventy miles north of Porto Rico, in the West Indies, is the next deepest cast known, viz., 4,561 fathoms, or 27,366 feet; not far inferior to the Pacific depth, but here the deep area must be comparatively small, as shallower soundings have been made at distances sixty miles north and east of it.

A similar depression has been sounded during the last few years west of the great range of the Andes, at a distance of fifty miles from the coast of Peru, where the greatest depth is 4,175 fathoms.

Other isolated depths of over 4,000 fathoms have been sounded in the Pacific. One between the Tonga or Friendly Islands of 4,500 fathoms, one of 4,478 fathoms near the Ladrones, and another of 4,428 fathoms near Pylstaart Island, all in the Western Pacific. They all require further investigation to determine their extent.

With these few exceptions, the depth of the oceans, so far as yet known, nowhere comes up to 4,000 fathoms, or four sea miles; but there can be little doubt that other similar hollows are yet to be found.

The sea with the greatest mean depth appears to be the vast Pacific, which covers 67 millions of the 188 millions of square miles composing the earth's surface.

Of these 188 millions, 137 millions are sea, so that the Pacific comprises just one-half of the water of the globe, and more than one-third of its whole area.

The Northern Pacific has been estimated by Mr. John Murray to have a mean depth of over 2,500 fathoms, while the Southern Pacific is credited with a little under 2,400 fathoms. These figures are based on a number of soundings which cannot be designated otherwise than very sparse.

To give an idea of what remains to be done, I will mention that in the eastern part of the Central Pacific, there is an area of 10,500,000 square miles in which there are only seven soundings, whilst in a long strip crossing the whole North Pacific, which has an area of 2,800,000 square miles, there is no sounding at all. Nevertheless, while the approximate mean depth I am mentioning may be considerably altered as knowledge increases, we know enough to say that the Pacific is generally deeper than the other oceans. The immensity, both in bulk and area, of this great mass of water, is difficult to realise; but it may assist us when we realise that the whole of the land on the globe above water level, if shovelled into the Pacific, would only fill one-seventh of it.

The Indian Ocean, with an area of 25,000,000 square miles, has a mean depth, according to Mr. Murray, of a little over 2,000 fathoms. This also is estimated from a very insufficient number of soundings.

The Atlantic, by far the best sounded ocean, has an area of 31,000,000 square miles, with a mean depth of about 2,200 fathoms.

The temperature of this huge mass of water is an interesting point.

The temperature of the surface is most important to us, as it is largely on it that the climates of the different parts of the world depend. This is comparatively easy to ascertain. We know so much about it that we are not likely to improve on it for many years. We are quite able to understand why countries in the same latitude differ so widely in their respective mean temperatures; why fogs prevail in certain localities more than others; and how it comes about that others are subject to tempestuous storms.

On the latter point nothing has come out plainer from recent discussion than the fact that areas where great differences of surface temperature of the sea prevail are those in which storms are generated.

It is a matter of observation that in the region south of Nova Scotia and Newfoundland, many of the storms which travel over the Atlantic to this country have their rise.

An examination of surface temperature shows that in this region the variations are excessive, not only from the juxtaposition of the warm water of the Gulf Stream and the cold water of the Arctic current flowing southward inside of it, but in the Gulf Stream itself, which is composed of streaks of warm and colder water, between which differences of as much as 20° F. exist.

The same conditions exist south of the Cape of Good Hope, another well-known birthplace of storms. Here the Agulhas current of about 70° F. diverted by the land pours into the mass of water to the southward, colder by some 25°, and the meeting-place is well known as most tempestuous.

South-east of the Rio de la Plata is another stormy area, and here we find the same abnormal variations in surface temperature.

Yet another is found off the north-east coast of Japan with the same conditions.

These differences are brought about by the mingling of water carried either by the flowing of a powerful current turned by the land into a mass of water of different temperature, as is the case off the Cape of Good Hope, or by the uprising of lower strata of cooler water through a shallow surface stream, as appears to be the case in the Gulf Stream.

A remarkable point recently brought to light by the researches of Mr. John Murray in Scotch lochs is the effect of wind on the surface temperature. It has been observed that wind driving off a shore drifts the surface water before it. This water is replaced by the readiest means, that is to say, by water from below the surface rising to take its place. As the lower strata are in all cases cooler than the surface, a lowering of the temperature results, and we find, in fact, that near all sea shores off which a steady wind blows the water is cooler than further to seaward.

This has an important bearing on coral growth, and explains why on all western coasts of the great continents off which the trade winds blow we find an almost absolute dearth of coral, while on the eastern coasts, on which warm currents impinge, reefs abound, the coral animal flourishing only in water above a certain temperature.

Observations of the temperature of the strata of water between the surface and bottom have been of late years obtained in many parts. Compared with the area of the oceans they are but few, but our knowledge steadily increases every year.

The subject of the vertical distribution of temperature has not yet been thoroughly investigated in the light of the whole of the information which we now possess, but Dr. Alex. Buchan has been for some time devoting his spare time to the task, and it is a heavy labour, for the data obtained here and there over the world by different ships of all maritime nations are very difficult to collect and to appraise, but I understand that before long we shall have the result, which will prove very interesting, in the last volume of the *Challenger* series.

It will readily be understood that observations on temperatures at great depths require great care. In the first place, the thermometers must be most carefully manufactured. They must be subjected to rigorous tests, and they must be carefully handled during the operation. All observations are not of the same value, and the discussion, therefore, presents considerable difficulty and demands much discretion.

In the meantime we can state certain known facts.

We have learnt that the depth of the warm surface water is small.

In the equatorial current between Africa and South America, where the surface is of a temperature of 78°, at 100 fathoms it is only 55°, a difference of 23°, and a temperature of 40° is reached at 400 fathoms. In this region, so far as knowledge goes, the fall in temperature as we descend is most rapid, but generally speaking the same variations prevail everywhere.

In the tropical Pacific the temperature falls 32° from the surface, where it stands at 82°, to a depth of 200 fathoms, 40° being reached at from 500 to 600 fathoms below the surface.

Below the general depth of from 400 to 600 fathoms, the temperature decreases very slowly, but there is considerable variation in the absolute amount of it when we get to great depths in different parts of the ocean.

One of the most interesting facts that have been recognised is, that in enclosed hollows of the ocean the bottom temperature is apparently much less than that of the stratum of water at a corresponding depth in the waters outside the submarine ridge that forms the enclosing walls, separating them from deeper areas beyond, and is, in all cases that have been observed, equal to that on the ridge. From this fact we are enabled to supplement our imperfect knowledge of depths, because if in a certain part of an ocean we find that the temperature at great depths is higher than we know exists at similar depths in waters apparently connected, we can feel certain that there is a submarine ridge which cuts off the bottom waters from moving along, and that the depth on this ridge is that at which is found the corresponding temperature in the outer waters. As a corollary we also assume that the movement of water at great depths is confined to an almost imperceptible movement, for if there was a motion that we could term, in the ordinary acceptation of the word, a current, it would infallibly surmount a ridge and pour over the other side, carrying its lower temperature with it.

A notable instance is the bottom temperature of the North Atlantic. This is nowhere below 35° F., although the depths are very great. But in the South Atlantic at a depth of only 2,800 fathoms the bottom temperature is but a little above 32° F., and we are therefore convinced that somewhere between Africa and South America, though soundings do not yet show it, there must be a ridge at a depth of about 2,000 fathoms.

We also come to the same conclusion with regard to the eastern and western portions of the South Atlantic, where similar differences prevail.

Again, the few temperatures that have been obtained in the eastern South Pacific show a considerable difference from those in the South Atlantic, and we are compelled to assume a ridge from the Falkland Islands to the Antarctic continent.

It is interesting that the investigation into the translation of the great seismic wave caused by the eruption of Krakatoa in 1883, led to a similar and entirely independent conclusion. The wave caused by the explosion in the Straits of Sunda reached Cape Horn, where by good chance a French meteorological expedition had erected an automatic tide gauge, but instead of one series of waves being marked on the paper there were two. A little consideration showed that the South Pole having directly interposed between Sunda Straits and Cape Horn, the waves diverted by the land about the pole would arrive from both sides.

One wave, however, made its appearance seven hours before the other.

Study showed that the earlier wave coincided in time with a wave travelling on the Pacific side of the pole, with a velocity due to the known depth, while the later wave must have been retarded in its journey *via* the South Atlantic. The only possible explanation is that the wave had been impeded by comparatively shallow water.

The evidence from bottom temperature was then unknown, and thus does one branch of investigation aid another.

In the Western Pacific the water is colder, a few bottom temperatures of a little over 33° F. having been found in the deep trough east of the Tonga Islands; but the North Pacific, though the deeper ocean—of enormous area and volume—is apparently again cut off by a submarine ridge. The north-western part of the Indian Ocean is for similar reasons assumed to be divided from the main body, the shallower water probably running from the Seychelles to the Maldive Islands.

Mr. Buchanan has pointed out why some parts of oceans, deep and vast though they be, are when cut off from communication with others warmer at the bottom.

Water can only sink through lower layers when it is the heavier, and though a warm surface current becomes from evaporation denser, its heat makes it specifically lighter than the strata below.

It is only when such a current parts gradually with its heat, as in travelling from tropical to temperate regions, that it sinks and slowly but surely carries its temperature with it, modifying the extreme natural cold of the bottom layers.

In the North Atlantic and Pacific we have such a condition. The great currents of the Gulf Stream and Japan current as they flow to the north sink, and in the course of ages have succeeded in raising the bottom temperature three or four degrees.

In the southern seas this influence is not at work, and, directly connected with the more open water round the South Pole, there is nothing to carry to the abysmal depths any heat to raise them from their normal low temperatures, due to the absence of any heating influence.

The ice masses round the South Pole have probably little or no effect on bottom temperature, as the fresher, though colder, water will not sink; and, as a matter of fact, warmer water is found at a few hundred fathoms than at the surface.

The lowest temperature ever obtained was by Sir John Ross in the Arctic Ocean in Davis Straits at a depth of 680 fathoms, when he recorded a reading of 25°F. This probably requires confirmation, as thermometers of those days were somewhat imperfect.

In the great oceans the greatest cold is found on the western side of the South Atlantic, where the thermometer stands at 32°.3 F., but temperatures of 29° F. have been obtained of recent years east of the Færoe Islands, north of the ridge which cuts off the deeper waters of the Arctic from the Atlantic.

Though scarcely within the limits of my subject, which is the sea itself, I must say a few words on the sea floor.

The researches carried on in the *Challenger* revealed that while for a certain distance from the continents the bottom is composed of terrestrial detritus, everywhere in deep water it is mainly composed of the skeletons or remains of skeletons of the minute animals that have lived in the water.

In comparatively small depths we find remains of many shells. As the depth increases to 500 fathoms or so we get mainly the calcareous shells of the globigerinæ, which may be said to form by far the greater part of the oceanic floor.

In deeper water still, where pressure, combined with the action of the carbonic acid, has dissolved all calcareous matter, we find an impalpable mud with skeletons of the silicious radiolaria of countless forms of the greatest beauty and complexity. Deeper still, *i. e.*, in water of—speaking generally—over 3,000 fathoms, we find a reddish colored clayey mud, in which the only traces of recognisable organic remains are teeth of sharks and cetacea, many belonging to extinct species.

What the depths of these deposits may be is a subject of speculation. It may be that some day, as mechanical appliances are improved, we shall find means of boring, but up to the present no such operation has been attempted.

On the specific gravity of the water of the sea I can say but little except that it varies considerably.

It is not yet known for certainty how far the specific gravities observed at various points and depths remain appreciably constant.

In localities where evaporation is great, and other influences do not interfere, it is evident that the specific gravity of the surface will be high; a consideration which observations confirm, but there are many complications which require more observation before they can be resolved.

In some few places repeated observations permit deductions, but taking the sea as a whole we are yet very ignorant of the facts bearing on this point.

The waves which forever disturb the surface of the sea demand much study.

The greatest of these, and the most regular, is the tidal wave. On this many powerful intellects have been brought to bear, but it still presents many unsolved anomalies.

Lord Kelvin and Prof. Darwin have demonstrated that the tidal movement is made up of many waves depending upon different functions of the moon and sun, some being semidiurnal, some diurnal. The time of transit over the meridian, the declination of both bodies, create great variations; the changing distance and position of the moon and the position of her node, also have great effect, while the ever-varying direction and force of the winds, and the different pressure of the atmosphere play their part, and sometimes a very large part, on what is somewhat loosely known as the meteorological tide.

The amplitude of the oscillation of the water depending upon each of the astronomical functions varying for every point on the earth, the effect is that, each having a different period, the resulting mean movement of the water has most astonishing variations.

In some places there is but one apparent tide in the day; in others this phenomenon only occurs at particular periods of each lunation, while in the majority of cases it is the movements of each alternate tide only that appear to have much to do with one another.

Though after long observation made of the times and ranges of tides at any one spot, they can now be predicted with great accuracy for that particular place, the meteorological tide excepted, by the method of harmonic analysis, perfected by Prof. G. Darwin, no one yet can say what the tide will be at any spot where observations have not been made.

Observations all over the world have now shown that there is no part where the tidal movement is so regular and simple as around the British Islands. This is more remarkable when it is found that the tides on the other side of the Atlantic —at Nova Scotia, for instance—are very complicated.

The minor tides, which, in most parts of the world, when combined in one direction, amount to a very considerable fraction of the principal lunar and solar tides, and consequently greatly increase or diminish their effects, are in Great Britain so insignificant that their influence is trifling; but why this should be, I have never yet found any one to explain.

Nevertheless, there are many very curious points about our tides which are plainly caused by interference, or, in other words, by the meeting of two tidal waves arriving from opposite directions, or from the rebound of the tidal waves from other coasts.

This effect, also, it has been so far found impossible to predict without observation. On our southern coasts, for instance; in the western part the tide rises about 15 feet, but as it travels eastward the range becomes less and less, until, about Poole, it reaches a minimum of 6 feet. Farther east again it increases to Hastings, where the range is 24 feet. Yet farther east it again gradually diminishes. This is due to the reflection from the French coast, which brings another wave which either superposes itself upon, or reduces the effect of, the main tide advancing up the English Channel; but the details of such reflection are so complex that no one could forecast them without more knowledge than we possess.

There can be little doubt that to this cause, reflection, are mainly due the variations in the amount of mean range of tide which are found on many coasts at different parts; and as these reflected waves may arrive from great distances, and be many in number, we may cease to wonder at the extraordinary differences in range of tide which prevail, though it will be understood that this is wholly separate from the varying heights of each successive tide, or of the tide at different parts of each lunation, or at different times of the year, which depend upon the astronomical influences.

The actual height of the tide in deep water is small, but on passing into shallow water when approaching a shore, and especially when rolling up a gulf of more or less funnel shape, it becomes increased by the retardation caused by friction, and by compression laterally, and hence the height of the tide on a coast affected by other causes is greater than in the open sea.

The oceanic tide wave is supposed to be from 2 to 3 feet in height, but as this has been assumed from observations made at small oceanic islands, where, although the magnifying influences mentioned are at a minimum, they still exist, we wait for precise information until some means of actually measuring the tide in deep water is devised.

The waves due to wind, though not so far-reaching in their effects as the majestic march of the tide wave, are phenomena which are more apparent to the traveller on the ocean.

The deep sea in a heavy gale presents, perhaps, the most impressive manifestation of the powers of nature which man can behold, and doubtless many of us have experienced feelings that may vary from awe and wonder to sheer delight, according to the temperament of each individual, at for the first time finding himself face to face with this magnificent sight, though I rather fear that discomfort is the prevailing feeling that many carry away.

The height to which storm waves may rise has never been very satisfactorily determined. Apart from the difficulty of the task and the small number of people who will address themselves to it when they have the chance, it is but rarely that any individual sees really abnormal waves, even though he may be at sea all his life.

Different heights for what are called maximum waves have been recorded, and they vary from 40 to 90 feet from crest to hollow.

All we can say is that the most probable figure is about 50 or 60 feet.

These great storm waves travel very far. In some cases they convey a warning, as their velocity always far exceeds that at which the storm is travelling. In others they intimate that a gale of which no more is seen has occurred somewhere —it may be many miles distant.

When they have travelled beyond the limits of the wind which raised them, they lose the steepness of slope which characterizes them when under its influence, and become an undulation which is scarcely noticed when in deep water.

On approaching shallow water, however, they are again apparent, and the "rollers" that occur unperiodically at various places in latitudes where gales never occur would seem to be caused by such waves, originating in areas many thousands of miles distant. Such appears to be the origin of the well-known rollers at Ascension and St. Helena, where the rocky and exposed nature of the landing has caused this phenomenon to be especially noticed.

Other rollers are, however, undoubtedly due to earthquakes or volcanic eruptions occurring in the bed of the sea.

Many of the great and sudden waves which have caused devastation and great loss of life on the shores of western South America are referable to this cause.

Observations to enable the focus of such a disturbance to be traced have generally been lacking, but it is probable that where the wave has been large the point of origin has not been far distant.

In one notable instance the conditions were reversed. The point of origin was known, and the distance to which the resulting wave travelled could be fairly satisfactorily traced.

This was the great eruption in the Straits of Sunda, in August, 1883, which locally resulted in the disappearance of the major part of the island of Krakatoa, and the loss of nearly 40,000 lives, on the neighbouring shores of Java and Sumatra, by the huge wave which devastated them.

The records of automatic tide gauges and the observations of individuals enabled the waves emanating from this disturbance to be followed to great distances. These waves were of great length, the crests arriving at intervals of about an hour, and moving with a velocity of about 350 miles an hour, were about that distance apart.

The waves recorded at Cape Horn were apparently undoubtedly due to the eruption, and travelled distances of 7,500 miles and 7,800 miles in their course on either side of the south polar land.

They were only five inches in height above mean level of the sea, while the waves recorded at places on the southern part of Africa, at a distance of about 5,000 miles from the scene of the eruption, were from one to two feet high, the original long waves being of an unknown height, but probably did not exceed ten or fifteen feet.

No other such opportunity of testing the distances to which great waves may travel has ever occurred, and as such a catastrophe as gave rise to them could scarcely be repeated without similar loss of life, it may be hoped we shall not live to see another, interesting though the discussion of the numerous phenomena was.

The movement of the particles of water due to the tide wave extends to the bottom of the deepest water, and doubtless plays an important part in keeping up a constant motion in the abysses, but the depth to which the action of the surface waves originating in wind reaches is still but little known by observation.

If, however, we study the contour of the bottom off the shores of land exposed to the full influence of the great oceans, we are struck by the very general rapid increase of slope after a depth of about 80 to 100 fathoms (500 to 600 feet) has been reached.

It appears probable that this is connected with the depth to which wave action may extend, the fine particles brought down by rivers or washed from the land by the attrition of the breakers being distributed and gradually moved down the slope.

When we examine banks in the open sea we find, however, that there are a great many with a general depth of from 30 to 40 fathoms, and the question arises whether this may not be the general limit of the power of oceanic waves to cut down the mass acted upon when it is fairly friable.

The question has an interesting bearing on the subject of the ever-debated origin of coral atolls, for this is the general depth of many large lagoons; and, granted that the sea can cut down land to this depth, we have at once an approach to the solution of the problem of the formation of bases of a suitable depth and material upon which the coral animal can commence operations.

This question also awaits more light, and I merely offer this remark as a suggestion.

It is, however, somewhat remarkable that in recent cases of volcanic islands piled up by submarine eruptions, they have all been more or less rapidly washed away, and are in process of further diminution under the surface.

Observations on the mean level of the sea show that it constantly varies, in some places more than others. This subject has not yet been worked out.

In some localities it is plainly due to wind, as in the Red Sea, where the summer level is some two feet below that of winter, owing to the fact that in summer the wind blows down the whole length of the sea, and drives the water out.

In many places, as in the great estuary of the Rio de la Plata, the level is constantly varying with the direction of the winds, and the fluctuation due to this cause is greatly in excess of the tidal action.

In others the cause is not so clear.

At Sydney, New South Wales, Mr. Russell found that during eleven years the level was constantly falling at about an inch a year, but by the last accounts received it was again stationary.

The variations in the pressure of the atmosphere play an important part in changes of sea level.

A difference of one inch in the barometer has been shown to be followed by a difference of a foot in the mean level of the sea, and in parts of the world where the mean height of the barometer varies much with the seasons, and the tidal range is small, this effect is very marked.

Of any secular change in the level of the sea little is known. This can only be measured by comparison with the land, and it is a question which is the more unstable, the land or the water—probably the land, as it has been shown that the mass of the land is so trifling, compared with that of the ocean, that it would take a great deal to alter the general mean level of the latter.

All the points connected with the sea that I have had the honor of bringing before you form part of the daily observation of the marine surveyor when he has the chance, but I cannot refrain from also mentioning other duties, which are indeed in the present state of our knowledge and of the practical requirements of navigation the principal points to which he has to pay attention, as it may explain why our knowledge on so many interesting details still remains very imperfect.

Working as we do in the interests of the vast marine of Great Britain, the paramount necessity of good navigational charts requires that the production of such charts should be our principal aim.

It is difficult for a landsman and difficult even for a sailor who has never done such work to realize the time that is necessary to make a really complete marine survey. The most important part, the ascertainment of the depth, is done, so to speak, in the dark—that is to say, it is by touch and not by sight that we have to find the different elevations and depressions of the bottom of the sea.

In making a map of the land, an isolated rock or hill stands up like a beacon above the surrounding land, and is at once localised and marked, but a similar object under the sea can only be found by patient and long-continued sounding, and may very easily be missed.

When it is considered that marine surveying has only been seriously undertaken for about 100 years, with a very limited number of vessels, we shall, I think, understand how in the vast area of the waters, taking only those bordering the shores, many unsuspected dangers are yearly discovered.

Very, very few coasts have been minutely surveyed, and setting aside for a moment the great changes that take place off shores where sandbanks prevail, I should be sorry to say that even on our own coasts charts are perfect.

Yearly around Great Britain previously unknown rocks come to light, and if this is the case at home, what are we to think of the condition of charts of less known localities?

Our main efforts, therefore, are directed to the improvement of charts for safe navigation, and the time that can be spared to the elucidation of purely scientific problems is limited.

Nevertheless, the daily work of the surveyor is so intimately connected with these scientific problems that year by year, slowly but surely, we add to the accumulation of our knowledge of the sea.

Col. H. W. Feilden (the Naturalist to Sir George S. Nares's expedition in 1875–6), read a paper on *Current Polar Exploration*, beginning with Nansen's enterprise, of which he said:

I know of nothing in the entire history of Arctic adventure that surpasses the boldness and audacity of Nansen's conception. The risk he has calmly and voluntarily undertaken is tremendous. In what particular part of the Polar area the *Fram* may now be is a matter of hypothesis. After Nansen got beset in the Polar pack, his vessel must be entirely under the influence of the ice-drift. Neither steam nor wind can help her in any appreciable manner. We have every reason to believe that there is a steady circulation of water around the Pole, independent of the surface movements of the ice, caused by winds. This is proved by the fact of an ice-stream of enormous proportions flowing from the Polar area along the east coast of Greenland, passing between that island-continent and Iceland, glaciating Greenland and Cape Farewell, which latter lies in about the same latitude as the Shetlands, and finally meeting the Gulf Stream off the coasts of the United States. The smaller current which sets down Smith's Sound, between Grinnell Land and North-west Greenland into Baffin's Sea, points to the same conclusion. In my view the most hopeful indication of there being a tolerably rapid movement across the Polar area lies in the fact that the coast line of Grinnell Land, from Cape Union to the north-west, as far as it was explored by Sir George Nares's expedition in 1875 and 1876, is strewn with drift-timber, and the same occurs on the north shore of Greenland, from Repulse Bay to Cape Britannia. I paid particular attention to this drift-wood during my stay in Grinnell Land in 1875–76, and found that it was all coniferous. Though sadly battered by contact with the ice-floes, it often appeared comparatively fresh, pieces of bark adhered to it, and the abraded roots showed that the trees had been washed out whilst growing from the river banks. Now, there cannot be a doubt that this wood came from the Lena, Yenesei, or from some of the great rivers of Siberia. That this drift is constant and must have lasted for ages without any intermission is proved by our finding identically the same description of timber at all heights up to 1,000 feet in Grinnell Land. Even at this great elevation the timber had not lost its power of flotation, and burnt with a dull glow. You must not, however, suppose that this timber had been exposed to the elements for the long period that must have elapsed whilst Grinnell Land rose 1,000 feet above its present sea level. Stranded in fiords and bays it had been covered with glacio-marine mud-beds, filled with shells of recent Arctic mollusca and remains of mammals, &c. The melting ice-torrents subsequently cut through the mud-beds, and we wandered along dreary valleys, flanked by mud cliffs, and at the high elevations I have mentioned our footsteps crushed the shells of mollusca still retaining their brown epidermis, and held together by their hinges, whilst pieces of drift-timber were strewn around. A month ago, when in Spitzbergen, I carefully examined the drift-timber at the head of the bays and fiords which we visited. Precisely the same phenomena are visible in Spitzbergen as in Grinnell Land, so far as the secular elevation of the land is concerned, and the formation of glacio-marine beds; but the drift-timber of Spitzbergen is of quite a different description to that of Grinnell Land; some of it is baulks, and wood that has been used by man; it is evidently the *refectamenta* of the Gulf Stream and Atlantic Ocean, whilst the Grinnell Land drift undoubtedly comes from Siberia. I have entered into this long digression to indicate that there may be some hope of Nansen's audacious and magnificent project being safely accomplished; but, even if the *Fram* is lost, I have such confidence in the boldness and resource of the leader that I believe he and his companions will return to civilization.

Col. Feilden briefly noted the safe arrival of the Jackson-Harmsworth expedition at Archangel, and cautioned his hearers against the generally accepted belief that a successful landing on Franz Josef Land was a mere matter of detail. The later news received concerning the expedition justifies this caution.

He then referred to the loss of the *Ragnvald Jarl* and the abandonment of Mr. Wellman's dash at the North Pole. Feeling satisfied that the young journalist and his companions were once more in safety, Col. Feilden said:

Skill in Arctic navigation can only be attained by experience, and I venture to lay it down as a canon that the leadership of such an expedition should only be intrusted to a scientific sailor who has had such experience. In the case now before us, we have a plucky young American leaving his editorial chair in Washington and, without any practical acquaintance with ice navigation, crossing the Atlantic, hiring a ship in Norway, collecting his party of various nationalities, and starting off helter-skelter to make a rush for the North Pole, or to attain a very high northern latitude. Mr. Wellman's project (he gave it to the public through the Press) before he left for Spitzbergen was to place a depot on Danes Island, almost the north-western point of the Spitzbergen group, steam up to the Polar pack, jump off, and with dogs and sledges race over the floes. This, however, is a task far more difficult to accomplish than to set. The edge of the polar pack along the North Atlantic is not a solid line of ice, like a wharf or shore line; it is a confused mass of fragments, sometimes pressed together in chaotic forms, again opening out into loose ice under the influences of winds and currents, and leaving water spaces that a ship can pass into the favorite resorts of the whalers in old days. You must penetrate far into the pack, as Sir Edward Parry did in 1827, before you can hope to get on to an ice floe of sufficiently homogeneous nature and of sufficient extent to enable the travellers to pull their sledges and boats over its rough surface. Parry placed his ships in safe quarters in a convenient bay on the north of Spitzbergen, and after securing his base proceeded in rowing boats through the loose pack, until he found sufficiently firm ice to drag his sledges. We all know the result of his splendid endeavors. Parry found the southern drift of the ice-floes greater than his daily advance, so he was forced to abandon the enterprise, but for nearly 50 years his achievement marked the highest northern latitude attained by man, until his countrymen, under Sir George Nares and Admiral Markham, exceeded his limit, which was again surpassed by Lockwood in 1882 by 4 min. Mr. Wellman rushed his ship into the Polar pack, with the result that every student of Arctic literature could have foretold. So impressed was I with the extreme risk of Mr. Wellman's programme that when Captain Townley Parker invited me to accompany him this summer on board the R. Y. S. *Saide*, with a hint that our voyage might be extended to Spitzbergen, I gladly accepted his kind offer. Captain Parker before leaving England in May determined to visit Danes Island and convey European news to the members of the expedition that we expected to find there. The 27th of June saw us at Trómsö, with exactly one month in hand before the *Saide* had to be in Southampton Water. The yacht was filled up with coal to her utmost capacity—30 tons in the bunkers, and a deck-load of 20 tons in addition. This caused us considerable anxiety, as, after getting outside the islands off the Norwegian coast, on the morning of June 28th, we met with heavy weather, with a strong gale from north-west and rain and fog, and as we shipped a good deal of water we were greatly afraid that our precious deck-load might have to be thrown overboard.

Our course was laid for Bear Island. At mid-day of the 29th the ship was hove to for a couple of hours. Weather moderating, we proceeded under steam, and at 6 P.M. were fortunate enough to obtain good sights, which placed our position 67 miles out of our course to the eastward of Bear Island, so strong had the current been. Strange to say, we sighted no ice; it must have been all driven eastward by the gale. Altering our course, we steered to the north-west between Bear Island and Spitzbergen, and sighted Bear Island for a short time through the fog at 3 A.M. of June 30. At 4.30 P.M., the fog rising, the South Cape of Spitzbergen came into view 20 miles distant. Beautiful weather now set in, and the evening of July 1 saw us safely anchored in Advent Bay, Ice Fiord. There we were detained four days, partly to take in a supply of reindeer meat, and also by our finding the wreck of a Norwegian hunting vessel, and two days were spent in hunting for traces of the shipwrecked crew. Our efforts failed; the crew must have perished, but we brought away documents and clothing which showed their identity, and these were handed over to the Norwegian authorities on our return to Tromsö. We also had the advantage of sailing in with Edward Johannessen, of the *Anna*, and hearing his views about the *Ragnvald Jarl.* Early on July 5 we left Ice Fiord, and, steaming northward through a sea like oil, we passed outside Prince Charles's Foreland, and at 6 A.M. on July 6 we rounded Hakluyt's Headland and anchored in Smeerenberg Bay. There we found Captain Olsen of the *Familien*, driven down by the closing pack from the north-east, and his view as to the destruction of the *Ragnvald Jarl* was as positive as that of Edward Johannessen. Getting out the launch, we communicated with Professor Oyen on Danes Island, and left him a good stock of creature comforts. At 5 P.M. we had returned to Danes Island in the launch, steam was up, and Capt. Parker determined to run as far as he could in the direction of the Seven Islands to look for Wellman. Captain Olsen very kindly came on board the *Saide* to act as pilot if the pack forced us to run in close to the Spitzbergen shore, and I take this opportunity to acknowledge his services for he guided us, when nearing the shore, from several dangers and spots of foul ground, which, of course, we were unacquainted with, having no one on board who had previously visited this part of Spitzbergen. Leaving Smeerenberg Bay at 5.30 P.M. on the 6th, we headed north-north-east. At 9 o'clock the blink of the ice showed up, and by 10 P.M we got into loose sailing ice, in 80° 10′ N. The main pack was about two miles from us. I may mention that the *Saide* is entirely unprotected, and quite unfitted for contact with the ice-floes, and it would have been folly to enter close ice. As I viewed the pack from aloft it appeared to me of a formidable description, much of it floating 7 ft. to 8 ft. above water. The sea was as smooth as glass; not a breath of air disturbed the surface. The ice between which we glided showed all the lovely colours, from sapphire to emerald, which the memory of the Arctic voyager loves to dwell on. Altering our course to the eastward, we skirted the pack, working down the edge of it until we got abreast of Grey Hook. There we found the pack stretching in a semi-circle, enveloping Moffen Island, firmly wedged on Verlegen Hook, and stretching to Grey Hook. Wijde Bay appeared to be completely closed with ice. Knowing that there are no safe harbours amongst the Seven Islands, and that a ship lying there must be exposed to the almost certain risk of being beset and pressed on shore, and taking into consideration the very formidable character of the pack, I came at once to the same conclusion as the experienced walrus hunters, and felt that only a miracle could save Wellman's ship. It being quite impossible in our unprotected ship to get further east, and our coal supply having to be considered, nothing was left but to turn round and return to Smeerenberg Bay. About 1.30 on July 7 a complete change of weather took place. A heavy gale came up from the south-west, and we were glad, after a good shaking, to find ourselves, at 5 A.M., at anchor again in Smeerenberg Bay. All through July 7 the gale raged outside. Early in the morning of the 8th we proceeded to sea, and, again rounding Hakluyt's Headland, set our course to the southward. Captain Parker and I having come to the conclusion that Wellman's expedition had in all probability come to grief, it was deemed advisable to steam direct for Tromsö, taking with us Mr. Wellman's despatches and letters that had been left by him at Danes Island in May. The *Saide* reached Tromsö on July 12, and our views were at once circulated by the press. Though the definite news of the loss of the *Ragnvald Jarl*, on May 28, off Walden Island, did not reach Europe till August 2, the information brought by the *Saide* had quite prepared the authorities in Norway for the actual result, and the three weeks for preparation, which our information gave, was of considerable importance. I think, when I tell you that Captain Townley Parker is over 70 years of age, you will compliment him on his vigour and energy.

Col. Feilden closed with a reference to the magnificent work of Peary and his Norwegian friend, Astrup, in North Greenland, as of the highest geographical importance, and declared that all were looking forward with intense interest for their safe return by the end of September.

In Col. Feilden's opinion, North Spitzbergen is preferable to any other point as a base for expeditions in the direction of the Pole.

Dr. Hugh R. Mill offered the results of a bathymetrical survey of the English lakes. There are two types: one, represented by Derwentwater and Bassenthwaite, is broad and shallow, with an undulating bed, grooved and ridged; the second, comprising the other lakes, is characterized by steep sides and an almost flat floor. The following table shows the length, depth and volume of these lakes, as ascertained by Dr. Mill and his associates :

NAME.	Length, Miles.	DEPTH, FEET.		Volume, Million Cubic Feet.
		Max.	Average.	
Windermere	10.50	219	78½	12,250
Ullswater	7.35	205	83	7,870
Wastwater	3.00	258	134½	4,128
Coniston	5.41	184	79	4,000
Crummock	2.50	144	87½	2,343
Ennerdale	2.40	148	62	1,978
Bassenthwaite	3.83	70	18	1,023
Derwentwater	2.87	72	18	1,010
Haweswater	2.33	103	39½	589
Buttermere	1.26	94	54½	537

Mr. H. N. Dickson described his observations on the currents of the Faröe-Shetland Channel and the North Sea :

At all seasons Atlantic water is drawn from the Faröe-Shetland Channel and forced into the North Sea by the tides between Orkney and Shetland. The tidal streams run N. W. and S. E., and an eddy is formed to the northwest of the Orkneys, into which North Sea water is drawn, and perhaps also water from below. As the season advances the surface water of the North Sea becomes warmer; the upper layers probably receive smaller supplies of fresh water, but they become specifically lighter than the under layers. The upper layers becoming warmer than the Atlantic current, the surface of the North Sea becomes higher, and the surface water spreads into the Faröe-Shetland Channel, checking the supply of Atlantic water. Meanwhile the mass of Atlantic water seeks entrance into the North Sea. The controlling conditions are complex, but it appears that the greater the winter cold and the spring supply of ice-cold water from the Continent, the more slowly will Atlantic water penetrate into the North Sea below the surface; and the warmer the summer, the more will the surface supply be checked. At the same time the warmer the summer, the larger the quantity of Atlantic water seeking admission, and the greater its thermal power to drive back the axis of *maximum* weight.

Mr. H. Yule Oldham, in a paper entitled *A New Light on the Discovery of America,* indicated the three easiest points of access on the Atlantic Coast of the New World:

(1.) North America, by means of the convenient stepping-stones, Iceland and Greenland; (2.) Central America, with the help of the steady northeast trade-winds; (3.) Brazil, in South America, which is not only the nearest point to the Old World, but has the additional advantage of winds and currents tending in its direction. The Norsemen undoubtedly reached America by the first route; and Mr. Oldham's argument seems to be that, because the other routes were open, some discoverer or discoverers must have taken advantage of them before Columbus. Something like this may have been said before, but a man has the right to free his mind and to believe in discoverers who hide what they discover.*

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* Mr. Oldham has found a MS. map drawn by Andrea Bianco in 1448, and on this map an island, denominated *Authentic Island*, appears within the space occupied by Brazil in modern maps. This island Mr. Oldham is disposed to identify with the land said to have been discovered in the west by some Portuguese in the year 1447, as related by Antonio Galvano, in his *Discoveries of the World*, translated and published by Hakluyt in 1601.

The identification may be allowed, but it proves nothing. In every age chroniclers and map-makers accept statements and data which will not bear the light of fuller knowledge.

Galvano (whose name should be written Galvão or Galvam) gives the following circumstantial account, under the year 1428, of two maps much more remarkable than the one presented by Mr. Oldham:

"In the yeere 1428 it is written that Don Peter, the King of Portugals eldest sonne, was a great traveller. He went into England, France, Almaine, and from thence into the Holy Land, and to other places; and came home by Italie, taking Rome and Venice in his way: from whence he brought a map of the world, which had all the parts of the world and earth described. The Streight of Magelan was called in it The Dragons taile: The Cape of Bona Sperança, The forefront of Afrike, (and so foorth of other places:) by which map Don Henry the Kings third sonne was much helped and furthered in his discoueries.

"It was tolde me by Francis de Sosa Tauares, that in the yeere 1528, Don Fernando, the Kings sonne and heire, did show him a map, which was found in

The Climatology of Tropical Africa was the subject of a paper by Mr. E. G. Ravenstein:

He said that by ascending a mountain we might, even in tropical Africa, enter a region the mean temperature of which coincided with that of England, but if we at the same time considered the annual and daily ranges of temperature, we should find that a tropical climate differed exceedingly from that of the temperate regions. In the latter, the annual range was considerable, the daily range small. The character of a tropical climate was the very reverse, for there the difference between the coldest and warmest months of the year was small, while the difference between the temperature of day and night was very great. Nor could we escape these features even though we ascended the loftiest mountains to be met there. These conditions inevitably led to anæmia and racial degeneracy. Malaria prevailed throughout, even on the plateaus, and some of those explorers who had been loudest in praising the climate as being thoroughly well adapted to European constitutions had fallen victims to its deleterious influences. Europeans might certainly "live" in Africa with occasional holidays in Europe, and they could superintend native labour, but no locality had been discovered as yet where it would be advisable for European agriculturists and colonists to settle down. The districts most favourable to European settlers appeared to him to be some of the hill stations and the steppe-like plateaus which occupied so large an area in Eastern Africa, and extended southward into Cape Colony. Speaking of the rainfall, Mr. Ravenstein said that it was sufficient in most parts, but very irregular, so that works of irrigation would be required wherever agriculture on an extensive scale was to be carried on. The humidity, which in combination with great heat produced a climate very trying to the strongest constitutions, was, fortunately, not excessive over a considerable portion of Africa, including all the steppe-lands.

Mr. J. T. Buchanan described the researches made by the Prince of Monaco in the Atlantic and the Mediterranean in the summer of 1894. The tempera-

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the studie of Alcobaza, which had beene made 120 yeeres before, which map did set foorth all the nauigation of the East Indies, with the Cape of Bona Sperança, according as our later maps have described it. Whereby it appeereth, that in ancient time there was as much or more discouered, then now there is."

The final reflection, *whereby it appeereth*, is too freely rendered by Hakluyt. Galvano did not quite believe what he was told. He says: *Se assi he isto*, "if this is so," then in ancient, etc.

One consideration disposes of the matter. The Portuguese were wholly possessed by the spirit of maritime adventure. If they had learned in 1428, or in 1447, that there were lands beyond the Atlantic, they would have discovered the West Indies and Mexico and Central America and the South American Coast before the year 1492.

ture of the surface ranged between 15° and 17.4° Cent. (59° to 63° Fahr.), but rose under the influence of hot winds to 28° Cent. (82° Fahr.). In dredging, 89 black ground sharks of a very rare species were brought up from a depth of 7,316 feet, and some fishes, not yet identified, from a depth of 11,844 feet.

The geography of Lower Nubia, the region which will be flooded by the proposed Nile reservoir, was described by Mr. Somers Clarke, who held it to be of the utmost importance to make an exhaustive scientific investigation of the valley before it is drowned, with the temples of Philæ. Mr. Norman Lockyer thought that all the temples should be carefully surveyed and all the inscriptions transcribed and translated.

MR. PEARY'S GREENLAND EXPEDITION.—The steam sailing vessel *Falcon* arrived at St. Johns, N. F., on the 15th of September, bringing all but three of the North Greenland Expedition. Mr. Peary remains in the Arctic, with two volunteers, Hugh Johnson Lee and Matthew Henson, and will make an attempt during the next season to complete the work which was interrupted this year by the severity of the weather and the consequent reduction of the working force. The following letter to the New York *Sun*, of Sept. 16, relates the experience of the party:

"I was unable to carry out my plan last spring to reach Independence Bay, on the northeast coast of Greenland, on account of the terrible weather which set in after we had started on our journey. As I had planned, I made a very early start. We set out from Anniversary Lodge on March 6. The winter night was at an end, and the sun had risen above the horizon about two weeks before. The party comprised eight men—Astrup, who was my companion on the journey to the northeast coast in 1892, and Messrs. Entrikin, Lee, Baldwin, Vincent, Davidson and Clark. We had ninety dogs and twelve sledges. Five natives assisted us during the first two days of the march.

"Our intention was to make straight over the inland ice for Independence Bay, about 650 miles away. Our course was to be about midway between my outward and homeward track in 1892. Eight days after we started Lee and Astrup were compelled to return to our winter quarters. Lee had a frozen toe that rendered it impossible for him to go on with us. Astrup was ill and unfit for further marching. We were therefore crippled from the start, for we needed all hands if we reached the north coast in order to carry out my plan of dividing the expedition into three parties, each to undertake a certain part of the work.

"For the next six days, to March 20, we made slow progress, and on that day we were compelled to go into camp after making three miles. We could make no progress against the furious head wind. The temperature was 35° below zero. Entrikin, Baldwin and I occupied one hut, and Vincent, Clark and Davidson were in the other. Here we were imprisoned by the blinding storm for three days. On the 22d inst., two days after we went into camp, Vincent, Clark and Davidson were compelled to retreat to our tent to escape smothering. Davidson and Clark were considerably frostbitten.

"The storm subsided on the 23d inst., and we had our first opportunity to inspect the condition of the camp. We dug the dogs out of the snow that buried them. They were in a most pitiable condition. Some were dead and frozen solid under the snow. Many were frozen fast to the ice, and we had to chop them loose. The anemometer showed that the average wind velocity for thirty-four hours was forty-eight miles an hour. The thermograph showed that the average temperature had been 50° below zero. The lowest temperature during the storm was 60° below zero. We were encamped on the ice cap, 5,000 feet above the sea. I believe that this was the severest storm ever experienced by an Arctic party on a sledge journey.

"Davidson's frost bites made it necessary for him to return to Anniversary Lodge. Clark desired to continue with us. Davidson could not return to the winter camp alone, and so Dr. Vincent was detailed to go with him. They left us on March 24, and then our party was reduced to four men.

"We resumed the march. On the 28th inst., in a furious gale of wind, and with the snow drifting badly, Entrikin repaired a sledge, and while at this work he froze his feet badly. Still I determined to keep on, and we struggled ahead, fighting wind and weather as best we could until April 10. The dogs suffered greatly. They could not rally from the effects of the terrible equinoctial storm through which we had passed. Deaths occurred among them every day. To our dismay we found that the piblockto, or Greenland dog disease, which for many years has from time to time made great ravages among the native dog teams, had gained a firm foothold among our animals. We faced the probability that we would soon have no dogs to draw our sledges.

"The facts that my dogs were being exterminated, that we were still less than one-fourth the distance on our way, and that the season was getting late, decided me to return to our winter quarters and to save what provisions, alcohol, and so on, I could for another trial on the inland ice next spring. At our halting place, 125 miles on our journey, I cached a good quantity of supplies, and erected a prominent signal that will enable me to identify the spot next spring. Then we began the retreat under much difficulty.

"Entrikin's feet were now swollen and painful, and he was unable to walk. The dogs were dying every day. Clark and I were affected to some extent by snow blindness. The best day's march we had made to the north was eighteen miles, and we had to take a slower pace home. We reached Anniversary Lodge on April 20.

"Then we tried to do what work we could in the south. As early as possible, after his return to winter quarters, Astrup set out for Cape York, 150 miles to the south, and he was fortunate in being able, early in May, to complete the survey of the northern coast of Melville Bay. Most of the shore line of this bay, as is well known, had not been determined by earlier explorers.

"On May 16 I set out with Lee in search of Ross's Iron Mountains, near Cape York. After a journey of three weeks, during which the weather was incessantly stormy, we returned, having found the famous stones, which I photographed and measured. I built a cairn and deposited the record of the first white man who had looked upon them. When the *Falcon* took my party on board to return south I accompanied her to Cape York, and hoped to send one of the meteorites home by her, but the ice prevented the ship from making land. I hope I may have better success next season.

"Early last fall we carried supplies up on the ice cap for the spring sledging campaign. We were assisted in this work by the natives and the burros or Mexican donkeys that I had taken north. We were, however, able to carry the supplies only twenty-six miles inland.

"On Oct. 31 we met with quite a disaster. A tidal wave swept up Bowdoin Bay and washed up high on the beach where our house had been built. My steam launch, *Gen. Wistar*, was stove in. The whaleboat *Faith*, which had been part of my equipment on my expedition of 1891–2, was wrecked. My dories were also destroyed. All the barrels of kerosene had been scattered along the shore at some distance from one another. They were all swept into the sea, and only one-half of them were recovered. It was thus impossible to make use of the electric light plant during the winter.

"We occupied the winter in making preparations for the northern sledge trip. The manufacture of sledges was one of our chief occupations. We made sledge journeys by moonlight to secure food for our large number of dogs, and about 700 miles were thus covered. My burros did not live through the winter, and proved to be of little use. The carrier pigeons were destroyed by hawks and Eskimo dogs.

"The spring and summer before the *Falcon* came to take us home were devoted to surveying the neighboring bays and hunting deer. Two hundred and fifty deer were killed by the party. The auxiliary party on the *Falcon* was prevented by heavy ice from opening up communication with me until August 1, and the *Falcon* was not able to push her way through the ice up Bowdoin Bay and reach Anniversary Lodge until August 20.

"The auxiliary party made a trip to Ellesmere Land and searched the Carey

Islands for traces of the lost Swedish explorers, Björling and Kalstenius. They found some relics of them and the skeleton of a man on the Carey Islands, probably a sailor. They found no trace of the lost explorers at Cape Faraday or Clarence Head on Ellesmere Land, where it was hoped by the friends of the explorers that they had taken refuge. Jones Sound, south of Ellesmere Land, was blocked with ice, and it was impossible to push into it, so no exploration could be made in that direction.

" Mrs. Peary will return home with a daughter, aged one year, and accompanied by an Eskimo nurse from Bowdoin Bay.

" I shall make another attempt on the ice cap next spring. I shall utilize the Eskimos as a supporting party. They have done me good service throughout my sojourn in northwest Greenland, and I believe I will find them effective helpers on the inland ice. I have ample supplies of all sorts, including plenty of coal for the winter. All of the party are in good health.

" I am now, on August 29, about to leave the *Falcon* off Petowik Glacier, a little north of Cape York. The *Falcon* will proceed home, and I shall return in a whaleboat with Matt Henson and my Eskimo crew to Anniversary Lodge.

" R. E. PEARY."

It is not to be expected that the unfavorable conditions of 1894 will be renewed in 1895. Mr. Peary will undoubtedly finish what remains to be done in North Greenland, with which region his name is now permanently associated. Prof. Guido Cora proposes, in *Cosmos*, Series II., Vol. XI., Fasc. X.-XI.-XII. that the channel which bounds Greenland on the northeast be called by the name of its discoverer, and in his careful map of the coasts from Smith Sound to Lincoln Sea and Independence Bay, showing the results of the expeditions for the period 1871-1892, Peary Channel finds its appointed place.

The following extract from a letter, printed in a later number of the *Sun*, describes the unsuccessful attempt on the ice-cap :

On Tuesday morning, March 22, although the weather was still very unfavorable, we got under way, but the furious head wind and stinging drift, with the temperature of —35°, compelled us to halt after going only three miles, the dogs absolutely refusing to pull. Here we camped. Entrikin and Baldwin, with their double sleeping bag, took up part of the light protean tent, while the alcohol cooker and myself took the rest. The Doctor, in a single bag, and Clark and Davidson in a second double bag, occupied Astrup's little silk tent. The dogs were fastened as usual, each team was divided into groups, and, dinner over, we turned in. About 5 o'clock next morning I was awakened by a sudden increase in the force of the wind, which now blew with such violence that, had not our tents been all in one piece, connected with the floor cloth on which we were lying, I should have expected to have had it blown away at any moment.

The drift which accompanied this storm was almost indescribable, and had the members of the party been any less perfectly clothed than they were, it would have been impossible to have gone out of our shelter. As it was, however, Baldwin made his regular observations at the observatory sledge about 100 feet from the tent, and he and I took turns in carrying hot tea and pea soup to the three men in the silk tent, about fifty feet distant. Throughout the day and the following night the wind steadily increased in violence, until it became impossible to shout so as to be heard from one tent to the other, even with the utmost effort of our lungs.

On Thursday afternoon the drift forced an entrance into the silk tent, and in order to escape being smothered its occupants were obliged to get out as best they could and retreat to the larger tent. In doing this Davidson had his heel, and Clark a toe, two fingers and a thumb frost-bitten. As soon as they were safely in our tent, Entrikin turned out of his bag and gave his place to Clark. I turned my deerskin sleeping trousers over to Davidson, and the Doctor curled himself up on the foot of the big bag. This left a small space between the pole and the tent opening, in which Entrikin and I could stand. This space was constantly decreasing in size from the drift, which, in spite of our efforts, continued to force itself through the fly, after the entrance of the boys. After a time there was room for only one of us, and we alternated in standing up, steadying ourselves by the pole, now and then curling up on the snow drift for a few winks of sleep, and making tea several times during the night to warm up the boys and keep up their spirits. The straining and flapping of the tent, the deafening roar of the wind, the devilish hissing of the drift, the howling and screaming of the poor dogs, made a pandemonium never to be forgotten.

One consoling feature was the fact that, owing to the quality and construction of our fur clothing, no one of the party suffered severely from the cold while in the tent. Personally, though without sleeping bag or any other covering beyond my deerskin travelling garments, I was entirely warm and comfortable throughout the storm.

Early on Friday morning, March 23, the wind began to subside, and at 7 A. M. I was out looking upon a scene that made me sick at heart. Half my dogs were frozen fast in the snow, some by the legs, some by the tails, and some by both. Two were dead, and all were in a most pitiable condition, their fur a mass of ice and snow driven into it by the pitiless wind. Several had freed themselves and had destroyed the double sleeping bag and many of the harnesses which had been blown off the tripods. Baldwin's anemometer, barograph and thermograph, which, as the result of his ingenuity and perseverance, had kept on recording throughout the storm, showed that for thirty-four hours the average wind velocity had been over forty-eight miles per hour and the average temperature about —50° Fahr., with a minimum of over —60° Fahr. When these figures are considered in connection with our elevation of 5,000 feet, the unobstructed sweep of the wind, and the well-known fact that ice-cap temperatures accompanied by wind are much more trying to animal life than the same temperatures at sea level, it is believed that the judgment will be that this storm beat the record as the most severe ever experienced by any Arctic party. All Friday was spent in digging out the sledges, feeding the dogs, getting them in shape as far as practicable, and making and repairing harnesses.

Davidson's heel placed him entirely *hors de combat,* necessitating his return to the lodge, and I decided to send him back in charge of the Doctor. I made arrangements for them to start early on Saturday morning. Clark's frost-bitten hand was not injured to speak of, the effect being superficial only. His feet, however, were frost-bitten in several places, and, while their condition at present was not such as to incapacitate him from travelling, the chances were perhaps more than even that additional exposure might make them worse. As he, however, had said nothing of turning back, and I knew him to be desirous of keeping on, I felt that I could not send him back if he, after thoroughly understanding the *pros* and *cons* of the case, still wished to go ahead, and was willing to assume the entire risk and responsibility as to his own personal safety.

I told him, therefore, that it he went on beyond this point, and should have more trouble with his feet, he would be obliged to return alone on a ski, without sledge or dogs, as I could neither spare another member of the party nor dogs to bring him back.

I told him to talk the matter over with the Doctor and let me know his decision. An hour or two later, finding him at work on some harnesses, I asked him if he had made up his mind. He answered in his deliberate Yankee way, as if anything different had never occurred to him :

" Oh, I guess I shall go ahead all right, sir ;" and go ahead he did.

Thick weather delayed the departure of Dr. Vincent and Davidson till noon, when they finally left us, the Doctor afoot and Davidson wrapped in the fragments of the sleeping bag and seated upon one of the seven-foot sledges, drawn by five dogs. This further reduction of my party to four destroyed all possibility of carrying out my original programme. I felt that the party thus reduced should remain a unit, and this meant either the entire abandonment of the east coast work or its execution by the same party that did the northern work after its return to Independence Bay.

After they had gone the afternoon was devoted to strengthening and sewing up holes in the tent, and repairing the torn sleeping bags. A cache was also made of the supplies that were now superfluous owing to the reduced size of the party. A complete readjustment was made of sledges and loads. At night all four of us occupied the protean tent, Entrikin and Baldwin as usual in their double bag, and Clark in the Doctor's single bag, to which he had fallen heir.

I turned in with my feet thrust in an extra pair of dogskin trousers, and felt no need of any other covering. The next day we left camp, Entrikin, Clark and Baldwin each with a large sledge and a smaller trailer in tow, drawn by teams of eighteen dogs. This arrangement was necessary to enable us to take all of the supplies. What the handling of teams like this means only those who know something of the peculiarity of the Eskimo dog can understand. In spite, however, of their two days' rest after the storm, it troubled me to find that my dogs were not in condition, and after travelling seven miles in a temperature of —46° Fahr., with a fresh, south-easterly wind, we were obliged to halt and camp on their account.

The following day gave early promise of being a favorable one, but we had travelled only a short distance when the wind and drift met us again, and at the end of three miles forced us to camp. Tuesday, the 27th of March, was a bright sunshiny day with just a light north-easterly breeze, and comparatively high temperature (—30° Fahr.). The demon of the ice cap, however, had only begun to play his cards. Less than two miles away from the camp Baldwin's big sledge, while going over a huge marble-like sastrugi,* broke in the bend of one of the runners, and we were delayed an hour or two lashing another sledge alongside it, making a three-runner sledge. At the end of the fifth mile Entrikin's sledge, the "Long Serpent," ran upon the sharp edge of an ugly, ragged sastrugi, and hung there broken-backed. This ended the day's march, and we went into camp to unload and repair both sledges.

This was the first day since leaving the cache igloos that we had been able to see more than a few yards about us. The surface of the inland ice lay in long swells. Each successive one was slightly higher than the preceding, and all rose somewhat higher to our right and descended somewhat lower to our left. The surface was firm, yet cloth-like in texture, and the rasping of the sledge runners over it came to my ears crisp and resonant, even when three-quarters of a mile away. At frequent intervals were huge sastrugi, offspring of the storm, marble-like in whiteness and hardness, all pointing toward Kane Basin, whence the equinoctial storm had issued, and which, hurtling across the icy canopy of Prudhoe Land, had fallen upon the party at Equinoctial Camp.

Throughout the entire march there were constant mirage effects, causing curious distortions of the members of the party, sledges and dogs; and a white frost cloud of condensation accompanied each team. A brilliant parhelion also displayed its prismatic colors for an hour or two during the day. At this camp three of the dogs that were unable to go on were killed and used as dog food. After the dogs were fastened and fed, I found that the boys were so discouraged by the mishaps of the day that I made no attempt to have the sledges repaired, but fixed up a milk punch and had every one turn in.

The next morning the temperature by the spirit thermometer was —51° Fahr., rising later to —36° Fahr., but accompanied then by north-east winds and drift. In this weather and temperature, and without shelter, Entrikin and Baldwin repaired their sledges, and Clark overhauled and repaired all the harnesses. This simple statement conveys no idea of what this work really meant. While engaged in it Entrikin got the bottoms of his feet nipped, and this was the beginning of his serious trouble.

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* The *sastrugi* are long, wave-like ridges in the snow, perpendicular to the wind.

After his work was done the "Long Serpent" was a much stiffer and easier running sledge than before, and I had hopes that it would last to Independence Bay. Although it was after 6 o'clock when the sledges were completed, we harnessed up and went on for a few miles rather than camp a second night in the same place.

During this march the wind and temperature, acting upon the moisture of Baldwin's breath, froze his kooletah so rigid that he could neither walk nor turn his head, and was obliged to come into camp riding on his sledge. Here we were obliged to assist him in removing the ice and snow, which had almost completely closed the face opening of his kooletah.

The next day was clear, with temperature ranging from —36° to —40° Fahrenheit. With everything in repair and good surface over which to travel, we should have made good progress, but the wind and drift directly ahead were on hand again, and at the end of ten miles Entrikin's team balked, and, in spite of the assistance of Baldwin and myself, refused to go further. In his efforts to start the sledge, Entrikin strained his back, and this, together with his frost-bitten feet, put him in a decidedly sober mood. The next morning, when we awoke, Clark's nose, which had projected too far through the face of his kooletah, was frozen to his sleeping bag, and had to be thawed off by the warmth of the hands.

Entrikin was in no condition to march, so we remained in camp to give him a chance to rest and get in condition. The temperature during the day was well down in the minus forties, falling at 7 P.M. to —55°, and remaining throughout the night between —55° and —57° Fahr.

Every one except myself passed an exceedingly comfortless night. Being unencumbered by a sleeping bag, I was able, if my feet got chilly, to restore the warmth by pounding them upon the snow.

The next day we pushed ahead five miles more, but the work showed that Entrikin was not in trim to stand a good day's march. The continued low temperature, too, in the forties and fifties below zero, with the almost constant wind, gave my dogs no chance to recover from the effects of the equinoctial storm, and had a perceptibly numbing effect upon the physical and mental faculties of my party. One of my best dogs died this day from the effects of that storm. Several had frost-bitten feet, and were unable to pull properly. Others were passing blood. Lion, the hardy veteran of the previous trip, was laid up with a sore leg, and almost all the animals still had more or less of the snow of the equinoctial storm remaining in their coats.

As a last resort I decided to remain in this camp two days to give Entrikin a final chance, and to see if it was possible to get the dogs in any better condition. Throughout these two days the temperature was well down in the forties, below zero. The temperature in the tent at my head for the two mornings was 45° and 44° respectively. (45° and 44° below zero must be meant.)

On the morning of April 3 Entrikin's feet and back were in much better condition, and I felt encouraged to think that he could now keep on without further trouble. The going during the day was very good, the surface hard, smooth, and level, interrupted only occasionally by the big sastrugi. At the end of the day's march we had covered fifteen miles, but the encouraging effect of this was more than counteracted by an occurrence which gave me more uneasiness than any other mishap thus far. One of the dogs in Clark's team was attacked by the piblockto, and bit nearly all the dogs in both Clark's and Baldwin's teams before he was shot.

On April 4, for the first time, the day passed without mishap, and the end of the march found us 15¼ miles from the last camp.

The next day again we advanced fifteen miles. Soon after making camp at the end of this march it began snowing heavily, with a strong south wind. This was the beginning of a storm that confined us to the tent for the next three days, and gave the finishing stroke to my poor dogs. When the storm ceased many of them were buried completely in the snow, several frozen down, and two were dead from exposure. All our sledges were completely snowed in, and the tent itself half buried in a big drift.

The following march was only seven miles, and this distance was made with the utmost difficulty. Entrikin's feet were much worse, and two more of the dogs with the piblockto had bitten nearly every dog in the pack. One of these dogs, the Agitator, a powerful big wolfish brute, the last survivor of the dogs purchased on the Labrador coast, presented, just before he was killed, as savage and gory a spectacle as I have ever seen. He had run amuck through the team, and, half blind as he was with froth and blood, had been mercilessly torn and shaken by the dogs that he had attacked. As the rifle was leveled at him he stood exhausted and panting, with head and neck swollen to twice their natural size, ears torn in shreds, eyes bloodshot, bloody foam dripping from his jaws, and his entire body flecked with foam and blood and clotted tufts of fur. Though so weak that he could scarcely stand, he was just gathering himself for another spring at the dog nearest him, when the bullet passed through his brain, and he collapsed in a quivering heap on the blood-bespattered snow.

It was very evident that the dread disease had gained a firm foothold in my pack, and the end could not be far away.

On April 10, after taking an account of stock, so to speak, and turning the whole matter over carefully, I decided that it was not advisable to attempt to proceed any further this season. As to the condition of my party, Entrikin was now entirely out of the race with his frosted feet, and must return to the lodge. Baldwin was not entirely recovered from an attack of cramps at the last camp, and I feared another storm would bring them on again. Clark had both heels and great toes frost-bitten, and was having daily attacks of bleeding from the nose. All, however, showed true grit, and were willing to push on. But the crushing blow was the existence in my pack of the dreaded and incurable piblockto, induced by the extreme exposure of the past four weeks, and which, with continued work and exposure, might easily reduce my pack to half its present number, or even exterminate it entirely.

Another serious feature of the case was the lateness of the season. Instead of being at Independence Bay on the 1st of April, as I had planned, it was now the 10th, and we were only one-fourth of the way there. While I appreciated the fact that two, or perhaps three of us, could probably get as far as Independence Bay even in the existing state of affairs, anything beyond that would be entirely out of the question, and to do even this would consume all of my pemmican, alcohol, and other provisions, which could not be replaced, and would thus destroy every chance of a second attempt next spring. So we regretfully turned our footsteps back to Anniversary Lodge. We had travelled 125 miles north of our camp.

R. E. PEARY.

EXPLORATION IN LABRADOR.—Messrs. Low and Eaton, of the Canada Geological and Natural History, returned in August from a fifteen months' journey in Labrador.

They found the northern part of the peninsula to be a network of streams and lakes. One of the latter, Lake Mickanaw, is more than 100 miles in length and much wider than Lake Mistassini.

Mr. Low reports that the herds of cariboo, on which the Indians of the north depend for subsistence, did not make their appearance in 1893, and that many of the Indians perished by starvation.

It was found that the great iron-bearing formation stretches from Lat. 50° to Ungava Bay and covers an estimated area of 60,000 square miles.

In the spring of 1894, the Hamilton River was ascended, and many photographs of the Great Falls were obtained. The river, which is about as large as the Ottawa, descends about 800 feet in the length of the gorge, and the height of the Great Fall is about 300 feet. The steep sides of the gorge rise from 500 to 800 feet and contract in places below the Falls to 50, and even to 20, feet in width.

At the foot of the Falls Mr. Low found the charred remains of Cary's* boat and at the top of the cañon the bottle containing the memorial of his expedition.

THE PILOT CHART OF THE NORTH ATLANTIC, for September, says:

> A report received from Capt. Pothier, Br. Sch. *Urbain B.*, states that on a voyage from the West Indies to Nova Scotia he fell in with the derelict schooner *Fannie E. Wolston*, July 20, 1894, latitude 30° 16′ N., longitude 66° 26′ W. On boarding the derelict the hull was found to be in good condition; the masts, houses, hatches and bulwarks were gone; the anchors were still on the bows, and the name on the bow and stern still visible.
>
> On August 6 she was again sighted by Capt. Tompsett, Br. S. S. *Merida*, in latitude 34° 05′ N., longitude 67° 20′ W. The current at the time was setting northeast.
>
> Since this derelict was abandoned, October 15, 1891, she has been reported forty-four times. She has been a derelict 1,025 days, during which she has drifted 8,575 miles, and as she is supposed to be afloat yet, her track will probably be still further extended.

There might be, it should seem, a regulation requiring the master of a vessel to take measures for her destruction before abandoning her.

THE GULF STREAM.—The U. S. Hydrographic Office has issued, as Publication No. 110, an article on the Gulf Stream by Lieut.-Commander John E. Pillsbury, U. S. N.

The cause of the Gulf Stream is, he says, directly or indirectly the force of the wind, long continued from the same general direction.

The current from the south-east trade winds divides near Cape St. Roque into two branches, one flowing to the southward along the coast of Brazil, the other toward the West Indies.

The current from the north-east trade winds is obstructed by the South American coast and the Windward Islands; and the combined currents escape in part through the passages of the Windward Islands, while the remainder passes by the northern side of the West India Islands towards the coast of the United States. The current which enters the Caribbean encounters the coast of Honduras and escapes, part towards the south and part towards the Strait of Yucatan.

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* *Exploration on Grand River, Labrador*, in BULLETIN, A. G. S., No. 1, 1892.

Another movement of the water which probably contributes as much to form the Gulf Stream as the surface current due to the friction of the wind, is the water driven to leeward by the break of the waves. Where the wind is blowing in the same direction over a large area, the effect is a simultaneous movement of the surface toward the lee shore.

In the case of the Caribbean, a strong shore current is produced toward the Strait of Yucatan and southward along the Mosquito Coast. It is from this cause that violent shore currents are set up along the coasts of Cape Cod, New Jersey and North Carolina in northeast gales.

The irregularities of the Gulf Stream due to the varying wind can only be predicted in a general way. The force of the current is the result of average conditions, and a temporary abnormally strong wind in the trade region will not materially change the average.

The first part of a norther in the Gulf of Mexico will probably cause a strong Gulf Stream current, because the water is driven toward the Cuban shore, from which it escapes through the Straits of Florida. A wind blowing across the Stream does not change the position of the current. It simply throws the heated water by the break of the waves and transports it by friction beyond the usual limits, but the current of the Stream holds to its fixed position. The presence of Gulf weed is in no way a sure indication of current, for it is carried more by the waves than by the current. A wind blowing across the Stream may carry every particle of weed into the outside waters. A long continued southerly wind will, by the break of the waves, transport the weed well up toward Nantucket Shoals, 150 or 200 miles from the current of the Stream.

Barometric conditions are a fruitful source of abnormal variations in current in the Straits of Florida, but Lieut.-Commander Pillsbury doubts their effect in the Atlantic.

The average velocity of the current is greatest at the axis, which is rarely in the middle.

It is generally believed that off Cape Hatteras the thermometer is a sure indicator of the Gulf Stream, and that the strongest current coincides with the highest temperature. This, however, is not the fact. The warm water may or may not be accompanied by a current. The warmest water south-east of the Cape is the result of a very gentle flow from the trade region outside of the West India Islands, and the Gulf Stream itself is between this warm water and the 100-fathom curve.

THE GREAT SIBERIAN RAILWAY. (*See map at the end of the* BULLETIN.)—In the *Consular Reports* for July, 1894, Mr. J. M. Crawford, U. S. Consul-General at St. Petersburg, describes the railroad now in course of construction through the length of Siberia. The first stone of the work was laid by the Cesarewitch, May 12, 1891, at Vladivostok. There are three divisions of the road—the Western Siberian, from Tcheliabinsk to the Ob River (1,328 versts*), together with the middle Siberian section from the Ob to Irkutsk (1,754 versts), and the Vladivostok-Grafskaya section; the second division, comprising the sections from Grafskaya to Khabarovka (347 versts), and from Mysovskaya to Sretensk (1,009 versts); and the third division includes the road round Lake Baikal (292 versts), and the line from Sretensk to Khabarovka (2,000 versts). The total length is 7,112 versts (4,715 miles). From Tcheliabinsk to the Ob the road runs for the most part in a nearly straight line, through a level country. The gradients are not greater than 0.0074 and the curves have a radius of 1,750 feet.

Beyond the Ob the country is hilly, but the gradients are limited to 0.008, and the radii of the curves are 1,750 feet. From Atchinsk, on the Tchulym River, to Irkutsk, a distance of 1,191 versts, the line runs through a mountainous region and crosses the rivers at their summit levels, which are high and narrow, and here the gradients are 0.015, with curves of 1,050 to 1,000 feet. The construction of the roadbed is costly, the embankments being sometimes 70 feet in height. The Yenisei River is crossed on a bridge 3,150 feet in length, and the road then climbs to the summit level along the Berezovka River and the valley of the Sitik. The length of the ascent is 67 versts and in this distance there are 82 bridges and *pipes.*[*] The mountainous features continue with little interruption to the Irkutsk station, at the 3,065th verst. From Irkutsk the road follows the shore of Lake Baikal for 162 versts to Mysovsk. For part of this distance the line is carried in cuttings along the face of the granite crags and through a tunnel 8,330 feet long across the Zyrkyzunsk chain. From Lake Baikal the road follows and crosses the River Selenga and enters on the Vitimsk plateau; and beyond this climbs a branch of the Yablonovoi Mountains, the water-shed between the basin of the Lena and that of the Amur, and descends past the town of Chita to Sretensk. From this point the continuation is through the valleys of the Shilka and the Amur, and then 400 versts through the valley of the Ussuri, on the border of the Chinese Empire, to the terminus at Vladivostok.

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* 100 versts=66.29 miles.

The condition of the work on October 1, 1893, was as follows:

On the section from Tcheliabinsk to Omsk, 80 per cent. of the roadbed was completed, 28 bridges had been constructed, rails laid for 240 versts, and telegraphic communication opened with Omsk. On the second section of the Western Siberian line, all the necessary materials have been prepared, 751,000 cubic feet of earth work handled and three station buildings constructed.

On the middle Siberian section, between the Ob and Krasnoyarsk, final surveys had been made on 300 versts, and the engineers were engaged on the remainder, 833,000 cubic feet of earthwork had been completed, 20,000 railway ties had been prepared and 3,375 tons of rails received. According to the Minister of Ways and Communications, the middle Siberian portion of the road will be completed in 1898.

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[*] Probably a mistranslation for *tunnels*.

On the Ussuri line telegraphic wires have been laid for 377 versts. The station buildings have been completed and the road bed is nearly finished. Twenty-two locomotives and 368 cars and platform cars have been put on the line, and in November, 1893, 100 versts of the road were opened for traffic; and trains are now running over a distance of 184 versts.

The Transbaikal section will be begun in 1895.

The estimated cost of the work, as published by the Minister of Finance, is:

	RUBLES.
For the Tcheliabinsk-Ob Section	47,361,479
" " Ob-Irkutsk Section	73,272,898
" " Irkutsk-Mysovsk Section	22,310,820
" " Mysovsk-Sretensk Section	53,309,763
" " Sretensk-Khabarovka Section	117,555,835
" " Khabarovka-Grafskaya Section	18,737,882
" " Grafskaya-Vladivostok Section	15,661,015
	348,209,692

Errors amounting to 2,000,790 rubles in the figures for the last two sections, as printed in the *Consular Reports*, have been corrected in the addition.

The ruble is the paper ruble, equal to fifty cents, and the cost per mile is 37,020 dollars.

It is officially announced that the road from Tcheliabinsk to Omsk will be opened to traffic on the 15th of October, 1894.

WEST AFRICA AND THE CONGO STATE.—France concluded two treaties in August, one with the Republic of Liberia, the other with the Congo Free State. The treaty with Liberia makes the *thalweg* of the Cavally River the limit of that republic on the east, and bounds it on the north by the parallel, first of 6° 30′, then of 7°, N. Lat., up to the Anglo-French frontier of Sierra Leone.

It is stipulated that, *This line must in every case insure to France the entire basin of the Niger and its tributaries.*

France renounces the rights conferred upon her by ancient treaties to various points on the Grain Coast and recognizes the sovereignty of Liberia over the coast west of the Cavally River.

The Fifth, and last, Article reads:

> In recognizing the boundaries now fixed the Government of the French Republic declares that it binds itself only to the free and independent Republic of Liberia, and makes all reservations in case of that independence being impaired or in case of the Republic of Liberia alienating any portion of the territories recognized as hers by the present convention.

The treaty with the Congo Free State provides:

> ARTICLE 1. The frontier between the Congo Free State and the Colony of French Congo, after following the *thalweg* of the Ubangi up to the confluence of the Mbomu and of the Welle shall be as follows:—(1) The *thalweg* of the Mbomu up to its source. (2) A straight line joining the watershed between the Congo and Nile basins. From this point the frontier of the Free State is constituted by the said watershed up to its intersection with longitude 30°, E. of Greenwich.
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> ARTICLE 2. It is understood that France shall exercise, under conditions which shall be determined by a special arrangement, the right of police over the course of the Mbomu, with a right of pursuit on the left bank. This right of police may be exercised on the left bank of the river only in regard to persons caught in the act of trespassing on French territory or on the waters of the river and in proportion as pursuit by the French agents is indispensable to bring about the arrest of the trespassers. France shall have a right of crossing to the left bank to insure her communications along the river.
>
> ARTICLE 3. The posts established by the Free State north of the frontier,

stipulated in the present agreement, shall be handed over to agents accredited by the French authorities as they arrive on the spot.

ARTICLE 4. The Free State binds itself to renounce all occupation and to exercise in the future no political influence west or north of a line thus determined:—Longitude 30° E. of Greenwich (27° 40′ E., Paris), starting from its intersection of the watershed of the Congo and Nile basins, up to the point where it meets the parallel 5° 30′ N., and then along that parallel to the Nile.

This arrangement advances the northern boundary of the Congo State by nearly a degree of latitude and extends the French Congo directly through the Sudan to the Nile.

The Congo State gives up the Bahr-el-Ghazal region, leased to it by England, which had already relinquished in deference to Germany the 25-kilometre strip between Lakes Tanganika and Albert Edward; so that the Anglo-Congolese convention of May 12, 1894, is now a dead letter.

EMIN PASHA'S MURDERERS.—According to the London *Times* of July 17, Baron Dhanis, in a letter written from the Congo, reports the capture of Ismaila Mamba and Gaonga, and their trial by a court-martial, which found them guilty of the murder of Emin Pasha. Piani Kitma and N'Tambwe, charged with conniving at the murder, were also in custody, and with them the Arab chief Mserera and his son, who are accused of killing Lieut. Michiels and Major Hodister.

The subsequent proceedings have not been reported.

THE NILE RESERVOIR.—At the Seventh Ordinary General Meeting of the Egypt Exploration Fund, held May 23, 1894, the President, Sir John Fowler, spoke on the subject of the proposed reservoir in the valley of the Nile.

The various schemes proposed were mentioned in order, beginning in the North with that of Mr. Cope Whitehouse for the utilization of the Wady Raian, the extensive depression in the desert immediately south of the Fayum, and consequently near the site of the ancient Mœris. To give practical effect to this suggestion, the President said, it would be necessary to provide a large ingress canal from the Nile, and an equally large egress canal, so that flood waters might flow into the Wady Raian and irrigation waters be drawn off from it; and it would also be necessary to construct an extensive dam across the entrance to the Wady.

This scheme avoided a dam across the river and interference with antiquities; but the estimated cost of the works and the annual expense of dredging and maintaining the canals, left no alternative but to decide against it. Furthermore, the area of land to be improved by this plan, if adopted, was, in the words of Sir John, "the least of all the schemes."

The scheme next in order was that of a dam or barrage across the Nile at Silsilis. At this point the bed of the river consists of a very soft sandstone rock, with beds of clay; and the Commissioners unanimously rejected this plan.

Two sites available for a dam were found at the First Cataract: one to the south of the island of Philæ, at Kalabshe, where the rock is strong and good, and the dam would not interfere with the island, though the work would be costly; the other, to the north of

Philæ, and suitable in every way but one, and that one should condemn it. If the dam were established at this point, the waters would entirely overwhelm the island of Philæ. After stating these facts, Sir John Fowler adds:

> It is not surprising, under these circumstances, that a majority of the Commissioners rejected all other alternatives, and adopted Philæ as a site; and so far I agree with them.

Sir John is, perhaps, not easily surprised, but he seems to have felt compunctious visitings about the contemplated destruction, for on the 11th of July he wrote to the Secretary of State for Foreign Affairs to express the solicitude of the Egypt Exploration Fund for the antiquities of Egypt, as of priceless value in the history of the world.

It is not to be supposed that representations or protests will have any great weight with the authorities who have the matter of the reservoir in hand. Governments are not to be reached; and between the British Government, which does not appear, and the Egyptian Government, which is the shadow of a name, there is no one to bear the responsibility of wrong-doing in Egypt.

A storage reservoir for the flood waters of the Nile is declared to be a necessity for the development of Egyptian agriculture and the greater comfort of the people; but it is not said what is to become of the 30,000 peasants whose homes are to be involved in a common ruin with the temples of Philæ.

Mr. Cope Whitehouse, but for whom there would be no Nile reservoir, does not accept the view of the Wady Raian project taken by the Commissioners and by Sir John Fowler. He declares that no reservoir is required for Upper Egypt, the low-Nile daily flow at the cataracts of Assuan being 30,000,000 cubic metres. The total amount required to give Upper Egypt all that it longs for but may not touch, to maintain existing areas in the Delta and extend cultivation to the coast-line and the Menzaleh bank of the Suez Canal, is only 3,600 million cubic metres. It is in the neck above the Delta that the drainage-canal and flood-escape are needed.

As to the cost of the Wady Raian project, Mr. Whitehouse, in his calculation furnished to the Foreign Office in 1887, estimated it at about £1,000,000. In 1890 he repeated this approximate calculation; but Lord Cromer, in 1891 and 1892, puts the cost at £1,500,000. Even this estimate is £500,000 below that of the proposed reservoir at Assuan.

At the sitting of the Technical Commission, held on the 27th of March, Mr. Whitehouse was asked to explain his project. This he did, and the result is set forth in an article in *Engineering*, of June 15, 1894, as follows:

> Mr. Cope Whitehouse . . . . concluded by asking the Commission to reject the Raiyan project, prepared by Mr. Willcocks, as wholly impracticable. M. Boulé and M. Torricelli thereupon remarked that "the project of Mr. Cope Whitehouse was entirely different from that which had been submitted to the Commission, and that before passing upon it it would be necessary to study it and prepare estimates of its cost." This was not done. The objections of the Commissioners are now stated to be three in number. . . . . Taking the objections in order, they are:
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> 1. The cost of the plan proposed by Mr. Willcocks. This is put at 3,700,000*l.*, against Colonel Western's estimate of 827,000*l.*; and Mr. Willcocks' own previous estimate of 1,479,247*l.* The discrepancy in the figures given by the Public Works Ministry at different times is bewildering. In his notes on the Wadi Raiyan scheme of December, 1888, Sir C. Scott Moncrieff said that in the previous April he had submitted to the Council of Ministers a note "summing up

the results of Colonel Western's careful survey and study of Mr. Cope Whitehouse's Wadi Raiyan project. Since then we have received no fresh information on the subject, except that there seems a likelihood of the rock in the great cutting into the valley being softer than Colonel Western anticipated." . . . .

2. The Commissioners object to the Wadi Raiyan because it will only supply Lower Egypt. But it is clear that as long as the Nile furnishes a minimum of 25,000,000 cubic metres daily at Assouan, and the total maximum consumption of water possible above the Raiyan reservoir is only 11,600,000 cubic metres, no reservoir is required for Upper Egypt. This point appeared to be settled beyond all further discussion by Major Brown in his work (page 107), which was recognized as an official publication and a standard authority on the subject.* . . . .

3. The Technical Commission also decided that the reservoir would be a menace to the lower part of the Fayoum, and might cause dangerous springs through (possible) fissures in the limestone rock. No such possibility was considered as within the range of reasonable probability by the Public Works Ministry from 1886 to 1894. Major Brown's excellent treatise was largely written to show that the Fayoum had been a vast lake for thousands of years, and that the water, under a pressure of over 200 ft., had never passed into the Raiyan depression. In modern times, with a difference of 35 ft., there has been no percolation.

What with official obstruction and official arithmetic, one thing appears to be settled: there will be no reservoir in the Wady Raian.

There will be delay in adopting a plan for a storage reservoir, but the one finally chosen will, undoubtedly, be that which is condemned by the right sentiment of the civilized world.

The men in power, who declared that in 1890, for the first time in history, forced labour had ceased, and was thenceforth abolished in Egypt, and confessed in 1894 that they had profited in the previous year by the forced, unpaid labor of 53,000 peasants, will destroy without a pang the resting-place of Him who sleeps in Philæ.

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* The Fayûm and Lake Moeris, by Maj. R. H. Brown. 4to. London, 1892.

THE ROYAL SOCIETY OF NEW SOUTH WALES offers its Medal and £25 for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon each of the following subjects:

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All communications to be addressed to the Honorary Secretaries.

T. W. E. DAVID,
J. H. MAIDEN,
Hon. Secs.

THE SOCIETY'S HOUSE,
5 ELIZABETH STREET,
Sydney, 13th December, 1893.